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Indian Standard

RECOMMENDED CRITERIA FOR ADOPTABILITY OF DIFFERENT IRRIGATION METHODS

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Indian Standard

RECOMMENDED CRITERIA FOR ADOPTABILITY OF DIFFERENT IRRIGATION METHODS

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Indian Standard

RECOMMENDED CRITERIA FOR ADOPTABILITY OF DIFFERENT IRRIGATION METHODS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 27 May 1986, after the draft finalized by the Irrigation Equipment and Systems Sectional Committee had been approved by the Agricultural and Food Products Division Council.

0.2 Irrigation water may be applied to crops by flooding it on the surface, by applying it below the soil surface, by spraying it under pressure or by applying it in drops. The correct method of application of irrigation varies with the source of water, type of soil, topography of the land and the crop to be irrigated. To facilitate the adoption of a particular method of irrigation this standard has been prepared.

0.3 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the criteria for adopting different methods of irrigation.

2. TERMINOLOGY

2.0 For the purpose of this standard the following definitions shall apply.

2.1 Irrigation methods shall be of following types.

2.1.1 *Surface Irrigation* — Water is applied directly to the land surface from a channel located at upper reach of the field. It shall be of the following types.

*Rules for rounding off numerical values (*revised*).

2.1.1.1 *Border strip method* — In this method water is introduced at the upper end of a strip of land and it flows between the low levees (bunds) to the lower end. The land is level between levees but has natural slope lengthwise.

2.1.1.2 *Check basin method* — This method consists in dividing the area into square or rectangular plots and irrigating each plot. The plots are generally level or have a very mild slope. The term check border is also used to describe this method of irrigation. The basin method of irrigation is a modification of the check basin method used for irrigation of orchards. Basins are constructed for each tree or group of trees. Water is conveyed to each basin, either by flowing through one basin into another or through a channel separately constructed.

2.1.1.3 *Furrow method* — This method consists in making the land into ridges and furrows and irrigating the area through furrows.

2.1.1.4 *Corrugation method* — This is a method of irrigating close growing crops using small closely spaced-furrow shaped channels called corrugations. They are constructed along the slope of the field and water moves down through several corrugations at a time. Unlike deep furrows, water in corrugations overtop them during flow.

2.1.2 *Sub-surface Irrigation or Sub-irrigation* — In this method water is applied below the ground surface by maintaining an artificial water table at some depth and is made available to plants through capillary action. Topographic conditions can permit natural water application through sub-irrigation as well.

2.1.3 *Sprinkler Irrigation* — In this method water is applied above the ground surface in the form of spray resembling rainfall. The spray is developed by the flow of water under pressure through small perforations or rotary nozzles.

2.1.4 *Drip or Trickle Irrigation* — This is a method of application of water directly to the land surface or below the surface near the plant root in small quantities but continuously. Water application is accomplished through an extensive network of small diameter pipes fitted with emitters or drippers.

3. INFILTRATION CHARACTERISTICS OF SOIL

3.1 For the purpose of deciding the method of irrigation and its subsequent design the infiltration characteristics of the soil should be understood. Infiltration is the downward flow of water into the soil. In irrigation practices, it is also known as water intake. The term infiltration applies to a level soil surface covered with water, whereas, the water

intake refers to a particular soil surface configuration such as furrow. The infiltration is much higher at the beginning and decreases with time. It is influenced by soil properties and moisture gradient. In surface irrigation, the depth and velocity of flowing water also influence the infiltration. The infiltration is either expressed as accumulated or cumulative infiltration, instantaneous infiltration rate, average infiltration rate, or basic infiltration rate.

3.1.1 *Accumulated or Cumulative Infiltration* — It is the volume of water per unit of surface area entering into the soil at the end of a given time. The volume per unit area may also be expressed as depth of infiltration.

3.2 Instantaneous Infiltration Rate — It is the rate at which water enters into the soil at a particular time. Thus it is the volume per unit area per unit time. In terms of the accumulated or cumulative infiltration, it may be expressed as:

$$I_r = \frac{\partial(I_c)}{\partial t} \tag{1}$$

in which I_r = instantaneous infiltration rate, I_c = accumulated or cumulative infiltration, and t = time.

3.3 Average Infiltration Rate — It is obtained by dividing the accumulated or cumulative infiltration with time as,

$$I_{av} = I_c/t \tag{2}$$

in which I_{av} = average infiltration rate. The average infiltration rate for a time interval from t_1 to t_2 shall be obtained as,

$$I_{av} = \frac{I_{c2} - I_{c1}}{t_2 - t_1} \tag{3}$$

in which I_{c_2} and I_{c_1} are values of the accumulated or cumulative infiltration respectively at the end of the time t_2 and t_1.

3.4 Basic Infiltration Rate — The infiltration rate decreases with time and approaches a constant value at large value of time. The constant value of the infiltration rate is known as basic or final infiltration rate. The basic infiltration rate is considered to be the point at which the change in the infiltration rate is 10 percent or less in an hour.

3.5 Intake Families — Infiltration shall be expressed by one of the following equations:

$$I_c = at^b + c \tag{4}$$

$$I_c = at^b + ct \tag{5}$$

$$I_c = a\,[\,1 - \mathrm{Exp}\,(-bt)\,] \tag{6}$$

$$I_c = a\,[\,1 - \mathrm{Exp}\,(-bt) + ct\,] \tag{7}$$

in which I_c = accumulated or cumulative infiltration, in cm; t = time in min, Exp = basic of the natural logrithms = 2·718, and a, b and c are characteristic constants. For the adoption of different irrigation methods, the soils can be placed in one of the eight infiltration groups called intake families. These intake families, as described by equation 4, are given in Table 1. The values of the characteristic constants a, b and c in equation 4 and the basic infiltration rates are the criteria in defining the intake families.

TABLE 1 CHARACTERISTIC CONSTANTS VALUES FOR DIFFERENT INTAKE FAMILIES

Intake Family Symbol	Characteristic Constants			Basic Infiltration Rate (cm/h)	Infiltration Characteristics
	a	b	c		
A	0·062	0·661	0·7	0·05	Very slow
B	0·093	0·721	0·7	0·75	Slow
C	0·119	0·756	0·7	1·25	Moderately slow
D	0·178	0·785	0·7	2·50	Moderate
E	0·228	0·799	0·7	3·75	Moderately rapid
F	0·275	0·808	0·7	5·00	Rapid
G	0·365	0·816	0·7	7·50	Very rapid
H	0·444	0·823	0·7	10·00	Extremely rapid

3.6 Measurement of Infiltration — Infiltration may be measured by cylinder infiltrometers, volume-balance method, inflow-outflow method, or sprinkler, pending and furrow simulators. The measurements in volume-balance and inflow-outflow methods are done with the flowing water. Whereas, in cylinder infiltrometers, ponding and furrow simulators point measurements are made with stagnant water. In the sprinkler simulator method artificial rain is created with the help of sprinkler and the measurements of infiltration rate are made by adjusting the water application rate. The infiltrometers, and the ponding and furrow simulators do not represent the actual water flow conditions during irrigation. The methods also do not take care of the soil heterogenity and variations in soil surface conditions such as cracks. The volume balance method is found to be most accurate for borders and the inflow-outflow for furrow irrigation. The design of sprinkler irrigation system needs the knowledge of the basic infiltration rate which can be measured with any of the methods. The infiltrometer method is most

easy and practical and shall be used to fair degree of accuracy for the measurement of basic infiltration rate.

3.6.1 The volume balance method is based on the principle of continuity and states that for any time period during which water is advancing down a border strip, the total volume of water infiltration into the soil is equal to the volume of water applied into the border strip minus the volume of water temporarily stored at the soil surface. In inflow-outflow method, about 30 m length of a furrow is selected and the water infiltration rate at a particular time is equal to the difference of the inflow and outflow water streams for the selected length of the furrow. The water infiltration rate is expressed as volume of water per unit time which may be converted into the depth of water per unit time using the following relationship:

$$\begin{array}{c}\text{Water infiltration rate}\\ \text{in depth per unit time}\end{array} = \frac{\begin{array}{c}\text{Water infiltration rate in}\\ \text{furrow in volume per unit time}\end{array}}{\text{Furrow width} \times \text{furrow length}}$$

4. CRITERIA FOR ADOPTION OF IRRIGATION METHODS

4.1 Border Irrigation — This method is suited to areas where soil depth and land topography permit the required land levelling with uniform low grade. This method is suitable for irrigating close growing crops and most suitable to soils having moderately to moderately high infiltration rates.

Three following kinds of border irrigation are practised.

4.1.1 *Graded Borders* — The graded borders have some slope in the direction of irrigation. The slopes, generally range from 0·1 to 0·5 percent, but higher slopes are used under unavoidable conditions. The slope selected shall not cause soil erosion problems. The stream size, dimensions of the border, time of irrigation are so adjusted as to get uniform application of water throughout the strip.

4.1.2 *Level Borders* — These borders have no slope in the direction of irrigation. Water is ponded until it infiltrates into the soil. Level borders generally have their ends closed and also known as check basins or check borders.

4.1.3 *Contour Borders* — While irrigating steep lands (lands greater than 2 to 3 percent slope), if borders are made longitudinally, it is difficult to get uniform application of water. Such borders also cause severe soil erosion problems. In such cases the land is converted into a series of borders in the transverse direction. These are known as contour borders.

Because of land topography it may not be possible to get uniform width of the contour borders.

4.2 Check Basin Irrigation — This method is suited to smooth, gentle and uniform land surface and for all types of soils for irrigating close growing crops as long as the crop is not affected by temporary inundation. This method is especially adapted to irrigation of grain and fodder crops in heavy soils where water is absorbed very slowy and is required to stand for a relatively long time to ensure adequate irrigation. It is also suitable in very permeable soils which must be covered with water rapidly to prevent excessive deep percolation losses at the upstream and, for reclamation of salt affected soils and for irrigation of orchards.

4.3 Furrow Irrigation — This method is well adapted to irrigate row crops and vegetable crops and crops which are subjected to injury from ponded surface water or susceptible to fungal root rot. Furrow irrigation is suitable to most soils except sand that have a very high infiltration rate and provide poor lateral distribution of water between furrows. The types of furrow systems and its adaptability is given in Table 2.

TABLE 2 TYPES OF FURROW SYSTEMS AND ITS ADAPTABILITY

Type of System	Principal Features	Where Adaptable
Flat land furrows	Essentially straight slopes less than 0·5 percent	Best suited for row crops
Contour furrows	Follows contours on steep land and hill sides	Suitable to irrigate steep and uneven slopes. Hazardous in high rain-fall areas
Furrows of miscellaneous shapes	Special cross-sections made because of unusual conditions	Adapted for special soil slope and crop production problems
Furrows of miscellaneous arrangements	Circuitous or broad based	Used in orchards and vegetable crops

4.4 Corrugation Irrigation — This method is suitable in loamy soils in which the lateral movement of water takes readily. This method is not suitable for clay soils, deep sandy soils and saline soils. Suitable to be used with borders having lateral slopes.

4.5 Sub-Surface Irrigation — This method is suited to soils having reasonably uniform texture and permeable enough to permit water to

move both horizontally and vertically within the crop root zone. The soil profile must also contain a barrier against excessive losses through deep percolation either a nearly impermeable layer in the substream or a naturally high water table on which a perched or artificial water table can be maintained throughout the growing season. Topography must be smooth and nearly level or the slopes are very gentle and uniform. The quality of the irrigation water shall be good.

4.6 Sprinkler Irrigation — This method can be used for almost all crops (except rice and jute) and on most soils. This method is particularly suited to sandy soils that have a high infiltration rate. Soils too shallow to be levelled properly for surface irrigation methods can be irrigated safely by sprinklers. It is especially suitable for steep slopes or irregular topography because of its flexibility for the topography and its efficient control of water application. If soil erosion is a hazard, sprinkler irrigation can be used in conjuction with contour bunding, terracing, mulching and strip cropping. Land levelling is not essential for irrigation with sprinklers. Sprinkler irrigation can be used to protect crops against frost and against high temperatures that reduce the quantity and quality of harvest. In this method the amount of water can be controlled to meet crop needs. Especially suited for regions of water scarcity where available water is insufficient to irrigate the command area by surface irrigation. Sprinklers are also suitable for irrigating plantation crops like tea, coffee, cardamom and orchards. It is not suited for the areas with vary windy and hot climate.

4.7 Drip Irrigation — This method can be used in areas with water scarcity and salt problems. For widely spaced crops like vegetables and fruit trees this system is more suitable. Drip irrigation permits the application of fertilizer through the system. Drip system operates on a much lower line pressure, thus provides a saving in energy requirement as compared to sprinkler irrigation. Most suitable for those crops which require frequent watering.

5. CROP ADAPTATION TO IRRIGATION METHODS

5.1 Crop adaptation according to different irrigation methods, are given in Table 3.

6. IRRIGATION METHOD ADOPTION TO SOIL AND LAND SLOPE GROUPS

6.1 Irrigation method adoption depending upon the soil and land slope group are given in Table 4.

TABLE 3 CROP ADAPTATION ACCORDING TO IRRIGATION METHOD

(*Clause* 5.1)

SL No.	CROP	NORMAL IRRIGATION APPLICATION PERCENT OF AVAILABLE MOISTURE	ADAPTED IRRIGATION METHODS						REMARKS
			Check Basin	Border	Corrugation	Furrow	Sprinkler	Drip	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	Wheat	50	x	x	x		x		
ii)	Barely	50	x	x	x		x		
iii)	Berseem	50	x	x	x		x		
iv)	Lucerne	50	x	x	x		x		
v)	Rape	40	x	x			x		
vi)	Sarson	40	x	x			x		
vii)	Raya	40	x	x			x		
viii)	Toria	40	x	x		x	x		
ix)	Potato	60				x	x	x	
x)	Gram	40	x	x	x		x		
xi)	Sugarcane	50		x		x	x		
xii)	Paddy		x	x					
xiii)	Maize	50	x	x		x	x		
xiv)	Bajra	40	x	x	x	x	x		
xv)	Groundnut	40	x	x		x	x		
xvi)	Sorghum	50	x	x		x	x		
xvii)	Cotton	50	x	x		x	x		Furrow irrigation is particularly useful
xviii)	Soyabean	50	x	x			x		
xix)	Moth	40	x	x		x	x		
xx)	Mash	40	x	x		x	x		
xxi)	Mung	40	x			x	x		
xxii)	Chillies	50	x		x	x	x		
xxiii)	Vegetables	60			x	x	x	x	Drip irrigation and sprinkler can be widely used for raising these crops

TABLE 4 IRRIGATION METHOD ADOPTION DEPENDING UPON SOIL AND LAND SLOPE GROUPS

(*Clause* 6.1)

Sl No.	Irrigation Method	Slope Group (Percent)					Intake Family								Remarks
		0 – 0·1	0·1 – 0·25	0·25 – 0·50	0·5 – 1·0	1·0 – 2·0	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	
		(Design Slope Percent)													
		Level	0·2	0·4	0·75	1·5									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
i)	Border strip		x	x	x			x	x	x	x	x	x		Almost suited to all soil except with very low and high infiltration rate
ii)	Check basin	x					x	x	x	x	x				Well suited for soils of moderate to slow infiltration
iii)	Corrugation		x	x	x	x	x	x	x	x					Particularly adapted for close growing crops
iv)	Furrow	x	x	x	x			x	x	x	x	x			Graded furrows are adapted in soils with high filtration and level furrows in soils with low infiltration
v)	Sprinkler	x	x	x	x	x	x	x	x	x	x	x	x	x	Soils varying from very low to very high infiltration rates
vi)	Drip	x	x	x	x	x	x	x	x	x	x	x	x	x	For maximum water economy where surface irrigation methods cannot be successfully adopted

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2